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REPORT

ON THE

DIFFERENCE OF LONGITUDE

BETWEEN

WASHINGTON

AND

OGDEN, UTAH.

BY

J. R. EASTMAN,
PROFESSOR OF MATHEMATICS, UNITED STATES NAVY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1876.

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DIFFERENCE OF LONGITUDE BETWEEN WASHINGTON AND OGDEN, UTAH.

UNITED STATES NAVAL OBSERVATORY,

December 10, 1875.

SIR: I have the honor to present the following report of special duty performed in compliance with your orders in 1874.

This work was undertaken at the request of Lieut George M. Wheeler, United States Engineers, to determine by the telegraphic exchange of clock-signals the longitude of the observatory at Ogden, Utah.

The observations and most of the computations at this observatory were made by myself. In the computations, I received valuable assistance from Assistant A. N. Skinner.

The observations at Ogden were made by Mr. John H. Clark, and the computations by Dr. F. Kampf.

The observations for time at this observatory were made with the Transit Circle, the transits of all objects except close circumpolar stars being recorded on the chronograph sheet.

The azimuth constant was obtained on four nights from observations of Polaris by means of a closely approximate clock correction. On October 31, it was obtained from all the stars by the method of least squares.

The level and collimation constants were determined by the method usually employed in the reduction of work with the Transit Circle.

The equatorial value of the reduction of each transit thread to the *mean thread* is given in the following table:

s.	s.	s.
B_1 +12.262	C_1 +4.097	D_1 − 8.171
B_2 + 9.713	C_2 +2.054	D_2 − 9.696
B_3 + 8.159	C_3 +0.002	D_3 −12.271
	C_4 −2.052	
	C_5 −4.096	

In reading the observations from the sheets, threads C_1 and C_5 are omitted, so that, where not otherwise noted, the printed transits are those observed either at the nine threads B_1, B_2, B_3, C_2, C_3, C_4, D_1, D_2, and D_3, or at the five threads of set C.

The following table gives the observed places of the stars, the reductions, the deduced clock corrections, and the residuals.

Observations at the United States Naval Observatory.

Date.	Number.	Object.	Seconds of Transits over Wires. I.	II.	III.	IV.	V.	VI.	VII.	VIII	IX.	Mean.	Instrumental Corrections.	Observed Place.	Adopted Right Ascension.	Clock Corrections.	v
1874.			s.	s.	s.	s.	s.	s.	s.	s.	s.	m. s.	s.	s.	h. m. s.	s.	s.
Oct. 15	1	γ Pegasi	25.7	28.4	30.1	36.4	38.5	40.7	47.0	48.7	51.2	7 38.52	− 0.92	37.60	0 6 47.92	−49.68	−0.02
	2	β Ceti	57.2	59.9	1.6	7.9	10.2	12.4	18.7	20.3	23.0	38 10.13	− 1.25	8.88	0 37 19.19	.69	−0.01
	3	ε Piscium	5.8	8.3	9.9	16.0	18.1	20.1	26.3	27.9	30.5	57 18.10	− 0.99	17.11	0 56 27.44	.67	+0.02
	4	Polaris	..	..	58.0	22.5	51.0	18.0	43.0	..	..	13 50.50	+ 21.63	12.13	1 13 22.36	+ 0.02	+0.02
	5	θ¹ Ceti	25.2	27.9	29.4	35.5	37.6	39.7	45.8	47.4	50.0	18 37.61	− 1.15	36.46	1 17 46.77	.69	+0.02
	6	η Piscium	25.6	28.2	29.9	36.1	38.3	40.5	46.8	48.4	51.1	25 38.32	− 0.91	37.41	1 24 47.74	.67	+0.04
	7	ξ¹ Ceti	0.9	3.4	5.0	11.2	13.3	15.3	21.5	23.1	25.6	7 13.26	− 0.98	12.28	2 6 22.54	.74	0.00
	8	γ Ceti	28.1	30.6	32.1	38.3	40.4	42.3	48.5	50.0	52.7	37 40.33	− 1.03	39.30	2 36 49.52	.78	−0.02
16	9	α Andromedæ	32.4	35.2	37.0	44.0	46.3	48.6	55.6	57.5	0.4	2 46.33	− 0.74	45.59	0 1 55.58	−50.01	+0.01
	10	β Ceti	57.5	0.2	1.8	8.3	10.4	12.6	19.0	20.6	23.4	38 10.42	− 1.23	9.19	0 37 19.19	.00	+0.02
	11	ε Piscium	6.0	8.7	10.3	16.5	18.5	20.5	26.7	28.2	30.9	57 18.48	− 0.98	17.50	0 56 27.45	.05	−0.04
	12	Polaris	..	..	58.0	23.5	48.0	18.5	42.0	..	..	13 50.00	+ 22.45	12.45	1 13 22.39	. .	. .
	13	θ¹ Ceti	25.4	28.2	29.7	35.8	37.9	40.0	46.2	47.7	50.4	18 37.92	− 1.14	36.78	1 17 46.78	.00	0.00
	14	η Piscium	25.9	28.5	30.3	36.4	38.6	40.8	47.0	48.8	51.5	25 38.64	− 0.89	37.75	1 24 47.75	50.00	0.00
	15	β Arietis	21.9	24.6	26.4	32.8	35.0	37.2	43.7	45.2	47.9	48 34.97	− 0.83	34.14	1 47 44.17	49.97	+0.02
	16	ξ¹ Ceti	1.0	3.6	5.2	11.4	13.5	15.6	21.7	23.3	25.9	7 13.47	− 0.96	12.51	2 6 22.55	49.96	+0.02
20	17	ε Piscium	7.2	9.9	11.5	17.5	19.7	21.8	27.9	29.4	32.0	57 19.66	− 0.97	18.69	0 56 27.46	−51.23	+0.01
	18	Polaris	17.0	3.0	6.5	..	..	..	38.5	41.0	..	13 52.82	+ 20.45	13.27	1 13 22.00	. .	. .
	19	θ¹ Ceti	26.7	29.4	31.0	37.2	39.2	41.3	47.4	49.1	51.6	18 39.21	− 1.12	38.09	1 17 46.80	.29	−0.05
	20	ο Piscium	27.4	30.1	31.7	37.9	39.9	41.9	48.2	49.7	52.2	39 39.89	− 0.96	38.93	1 38 47.73	.20	+0.04
	21	α Arietis	46.4	49.3	50.9	57.5	59.8	2.0	8.6	10.3	13.1	0 59.77	− 0.82	58.95	2 0 7.73	.22	+0.02
	22	ξ¹ Ceti	2.3	5.0	6.6	12.7	14.8	16.9	23.0	24.7	27.3	7 14.81	− 0.96	13.85	2 6 22.59	.26	−0.02
	23	γ Ceti	29.6	31.9	33.7	39.8	41.9	44.0	49.9	51.6	54.2	37 41.84	− 1.01	40.83	2 36 49.58	.25	−0.01
	24	α Ceti	24.8	27.4	29.0	35.0	37.1	39.1	45.2	46.9	49.4	56 37.10	− 1.01	36.09	2 55 44.86	.23	+0.01
29	25	ε Piscium	9.0	11.8	13.3	19.5	21.5	23.5	29.7	31.4	34.0	57 21.52	− 1.09	20.43	0 56 27.48	−52.95	+0.03
	26	Polaris	..	..	4.5	31.0	59.0	25.0	51.0	..	..	13 58.10	+ 16.15	14.25	1 13 21.42	. .	. .
	27	θ¹ Ceti	28.7	31.3	32.9	39.1	41.2	43.2	49.3	50.9	53.6	18 41.13	− 1.23	39.90	1 17 46.83	53.07	−0.08
	28	η Piscium	29.2	31.8	33.4	39.7	41.9	44.0	50.3	51.9	54.6	25 41.87	− 1.02	40.85	1 24 47.82	53.03	−0.03
	29	ο Piscium	29.4	32.0	33.6	39.7	41.8	43.9	50.0	51.7	54.3	39 41.82	− 1.08	40.74	1 38 47.79	52.95	+0.06
	30	β Arietis	25.2	27.8	29.5	36.0	38.2	40.5	46.9	48.6	51.3	48 38.22	− 0.97	37.25	1 47 44.29	52.96	−0.05
	31	α Arietis	48.5	51.3	52.9	59.5	1.8	4.0	10.7	12.4	15.1	1 1.80	− 0.95	0.85	2 0 7.83	53.02	0.00
	32	ξ¹ Ceti	4.4	7.1	8.6	14.7	16.9	19.0	25.0	26.7	29.3	7 16.86	− 1.09	15.77	2 6 22.69	53.08	−0.05
31	33	γ² Ursæ Minoris, S.P.	9.4	18.0	23.0	42.9	49.8	56.7	16.4	21.4	30.0	21 49.73	− 2.76	46.97	3 20 53.37	. .	. .
	34	71 Tauri	44.2	47.0	48.7	55.4	57.5	59.7	6.6	8.0	11.0	40 57.57	− 0.70	56.87	3 40 3.40	−53.47	−0.01
	35	ξ Persei	56.4	59.3	1.0	8.3	10.7	13.1	20.4	22.1	25.0	47 10.70	− 0.60	10.10	3 46 16.65	.45	+0.03
	36	γ Tauri	22.4	25.0	26.7	33.0	35.2	37.4	43.6	45.3	47.9	13 35.17	− 0.79	34.38	4 12 40.91	.47	+0.01
	37	ε Tauri	0.5	3.3	4.8	11.2	13.4	15.5	22.0	23.7	26.4	22 13.42	− 0.76	12.66	4 21 19.11	.55	−0.07
	38	α Tauri	26.5	29.1	30.8	37.1	39.3	41.4	47.6	49.4	52.0	29 39.24	− 0.79	38.45	4 28 44.94	51	−0.03
	39	9 Camelopardalis	1.4	7.8	11.5	26.4	31.9	36.8	51.7	55.5	2.0	42 31.67	+ 0.31	31.98	4 41 38.51	. .	. .
	40	ι Aurigæ	30.6	33.6	35.5	42.8	45.3	47.7	54.9	56.8	59.8	49.45.22	− 0.58	44.64	4 48 51.16	.48	0.00
	41	11 Orionis	7.0	9.7	11.4	17.7	19.8	22.0	28.3	29.9	32.5	58 19.80	− 0.79	19.01	4 57 25.55	.46	+0.02
	42	ε Ursæ Minoris, S.P.	..	..	29.6	45.0	0.0	15.0	45.0	56.0	15.4	59 44.67	− 5.17	39.50	4 58 46.04	. .	. .
	43	β Orionis	14.0	16.6	18.2	24.5	26.5	28.6	34.7	36.3	38.8	9 26.47	− 1.03	25.44	5 8 31.97	−53.47	+0.01

No. 18. Observed on B and D_1 and D_2.
No. 42. Observed on C_4, C_3, C_2, C_1, and B.

Constants.

Date.	*a*	*b*	*c*
1874.	s.	s.	s.
October 15.5	− 1.09	− 0.47	− 0.01
16.5	− 1.09	− 0.45	− 0.01
20.5	− 1.05	− 0.46	− 0.02
29.5	− 1.06	− 0.49	− 0.11
31.5	− 1.04	− 0.39	+ 0.01

Clock Corrections and Rates.

Date.	Sidereal Time.	Corrections.	Hourly Rate.
1874.	h. m.	s. s.	s.
October 15	1 40	− 49.717 ± 0.006	− 0.040
16	1 40	− 49.986 ± 0.006	+ 0.026
20	1 50	− 51.240 ± 0.008	+ 0.004
29	2 0	− 53.025 ± 0.013	− 0.042
31	3 30	− 53.480 ± 0.008	− 0.003

Assuming that the Transit Circle was very steady in position (see constants) during the progress of the work, the probable errors of the corrections given have been derived simply from the consideration of the clock corrections.

OBSERVATIONS AT OGDEN.

The following description of the observatory at Ogden and its location was furnished by Lieut. G. M. Wheeler:

"The observatory is located upon a low rolling mesa about 150 feet above the surface of the Weber River, and approximately one-eighth of a mile distant from the track of the Utah Central Railroad, and three-fourths of a mile from the depot of the Union Pacific Railroad. The building consists of three observing-rooms, the middle one being the dome-room. It has a stone foundation, brick superstructure. The western room contains two transit instruments mounted upon heavy stone piers, and all longitude determinations are referred to the center line of the most easterly one. The second instrument, placed upon the western one, is used for latitude observations, and for comparison of observations in the determination of personal equation.

"The valley of the Weber River has but little fall in this locality. A few rolling, broken mesas to the northeast and southeast form a noticeable feature. The Wasatch range, a heavy mass of mountains, lies to the east of the meridian of this place, the northerly part of its westerly deflection crossing the meridian line through the observing pier first mentioned.

"The transit instrument used was Würdeman No. 29, a new one, made expressly for this observatory.

"The chronometer used on October 15 was Negus No. 1511; on all other nights, Negus No. 1491 was used; both break circuit chronometers.

"A chronographic record was kept of all observations.

"The first set of time determinations is excluded from the mean corrections adopted for October 15 and 16, because the chronometer was taken from its accustomed stand to the railroad telegraph office for the purpose of exchanging signals with the distant station.

"The latitude of the observing pier, as derived from Dr. Kampf's observations in 1873, is $+41^\circ\ 13'\ 8''.65 \pm 0''.022$."

The observations for time, the reductions, and the deduced chronometer corrections and rates are given as furnished by Lieutenant Wheeler, in the following tables.

Observations at Ogden.

Date.	Clamp.	Names of Stars.	Observed Transit Corrected for Rate.	*Aa*	*Bb*	*Cc*	Corrected Transit.	*R*	Corrections of Chronometer.	Normal equations.
1874.			h. m. s.	s.	s.	s.	s.	s.	m. s.	
Oct. 15	W.	α Lyræ	18 38 58.02	+0.02	−0.09	0.00	57.95	41.08	−6 16.87	$o = -0.94 + 15.00\,\delta t + 1.59\,a - 2.11\,c$
		β Lyræ	51 43.50	+0.04	−0.08	−0.01	43.45	26.62	16.83	$o = -5.06 + 1.59\,\delta t + 19.40\,a - 8.41\,c$
		50 Draconis . . .	56 40.70	−0.57	−0.19	−0.02	39.92	22.86	17.06	$o = +1.99 - 2.11\,\delta t - 8.41\,a + 57.30\,c$
		γ Lyræ	19 0 31.75	+0.05	−0.06	0.00	31.74	14.89	16.85	$a = +0^s.260c \quad = +0^s.005$ for E.
		ζ Aquilæ . . .	5 55.50	+0.12	−0.05	−0.01	55.56	38.50	17.06	
		ι Lyræ	9 6.26	+0.03	−0.05	−0.01	6.23	49.35	16.88	
		d Sagittarii . . .	16 34.68	+0.24	−0.02	0.00	34.90	17.77	17.13	
	E.	τ Draconis . . .	24 13.11	−0.47	+0.15	+0.02	12.81	56.14	16.67	
		β Cygni	31 56.40	+0.07	+0.05	+0.01	56.53	39.74	16.79	
		κ Aquilæ . . .	36 25.44	+0.20	+0.05	0.00	25.69	8.68	17.01	
		γ Aquilæ . . .	46 34.71	+0.14	+0.09	0.00	34.94	17.88	17.06	
		α Aquilæ . . .	50 56.71	+0.14	+0.10	+0.01	56.96	39.92	17.04	
		ε Draconis . . .	54 51.90	−0.36	+0.38	+0.01	51.93	34.63	17.30	
		γ Sagittarii . . .	59 27 62	+0.10	+0.15	+0.01	27.88	10.87	17.01	
		3 Ursæ Maj., L. C.	20 6 35.43	+0.68	−0.14	−0.02	35.95	19.03	−6 16.92	
		SECOND SERIES.								
	E.	β Cephei . . .	21 33 19.68	−0.24	+0.18	0.00	19.62	2.52	−6 17.10	$o = +0.01 + 7.00\,\delta t - 1.89\,a$
		ξ Aquarii . . .	37 21.97	+0.13	+0.04	0.00	22.14	5.21	16 93	$o = -1.52 - 1.89\,\delta t + 9.57\,a$
		ε Pegasi . . .	44 18.96	+0.09	+0.06	0.00	19.11	2.26	16.95	$a = +0^s.167$ for W.
		11 Cephei . . .	46 22.27	−0.25	+0.21	0.00	22.23	5.36	16.87	$o = +0.48 + 7.00\,\delta t + 3.66\,a$
		μ Capricorni . .	52 45.08	+0.14	+0.05	0.00	45.27	28.34	16.93	$o = +2.59 + 3.66\,\delta t + 21.05\,a$
		79 Draconis . . .	57 36.13	−0.30	+0.26	0.00	36.09	19.18	16.91	$a = -0^s.122$
		α Aquarii . . .	22 5 38.16	+0.11	+0.07	0.00	38.34	21.34	17.00	Adopted $c = 0^s.00$
	W.	ζ Cephei . . .	12 47.87	+0.06	0.00	0.00	47.93	30.95	16.98	
		θ Aquarii . . .	16 31.10	−0.10	−0.01	0.00	30.99	13.85	17.14	
		γ Aquarii . . .	21 28.87	−0.08	−0.03	0.00	28.76	11.58	17.18	
		π Aquarii . . .	25 10.40	−0.08	−0.05	0.00	10.27	53.21	17.06	
		9 Draconis, L. C. .	30 38.63	−0.46	+0.18	0.00	38.35	21 58	16.77	
		226 Cephei . . .	35 22.08	+0.27	−0.23	0.00	22.12	5.36	16.76	
		ξ Pegasi . . .	41 30.52	−0.06	−0.04	0.00	30.42	13.28	−6 17.14	
		THIRD SERIES.								
	W.	ι Ceti	0 19 21.14	−0.07	−0.01	−0.02	21.04	3.63	−6 17.41	$o = +0.08 + 12.00\,\delta t - 0.60\,a - 2.05\,c$
		12 Ceti	29 57.01	−0.06	−0.01	−0.02	56.92	39.64	17.28	$o = +0.67 - 0.60\,\delta t + 8.48\,a + 5.41\,c$
		ξ Cassiopeæ . .	36 18.20	+0.03	−0.02	−0.03	18.18	0.95	17.23	$o = -0.25 - 2.05\,\delta t + 5.41\,a + 37.65\,c$
		α Cassiopeæ . .	39 42.71	+0.04	−0.01	−0.03	42.71	25.56	17.15	$a = -0^s.092$
		21 Cassiopeæ . .	43 43.63	+0.18	0.00	−0.07	43.74	26.57	17.17	$c = +0^s.019$
		μ Andromedæ . .	56 6.37	−0.01	0.00	−0.03	6.33	48.90	17.43	
	E.	ε Piscium . . .	1 2 44.65	−0.05	+0.05	+0.02	44.67	27.43	17.24	
		β Andromedæ . .	9 1.19	−0.01	+0.07	+0.03	1.28	44.18	17.10	
		τ Piscium . . .	11 3.85	−0.02	+0.06	+0.02	3.91	46.76	17.15	
		υ Piscium . . .	18 53.06	−0.03	+0.04	+0.02	53.09	35.86	17.23	
		θ^1 Ceti	24 4.23	−0.07	+0.02	+0.02	4.20	46.75	17.45	
		38 Cassiopeæ . .	27 14.99	+0.12	+0.05	+0.05	15.21	57.95	−6 17.26	

Observations at Ogden—Continued.

Date.	Clamp.	Names of Stars.	Observed Transit Corrected for Rate.	*Aa*	*Bb*	*Cc*	Corrected Transit.	*R.*	Corrections of Chronometer.	Normal equations.
1874.			h. m. s.	s.	s.	s.	s.	s.	m. s.	
Oct. 16	E.	α Lyræ	18 38 43.03	+0.02	+0.19	+0.10	43.34	41.06	−6 2.28	$o = +1.20 + 15.00\,\delta t + 4.82\,a - 0.74\,c$
		β Lyræ	51 28.63	+0.06	+0.18	+0.10	28.97	26.60	2.37	$o = -5.73 + 4.82\,\delta t + 15.62\,a + 18.22\,c$
		σ Sagittarii . . .	53 31.09	+0.34	+0.06	+0.09	31.58	29.16	2.42	$o = -9.58 - 0.74\,\delta t + 18.22\,a + 43.01\,c$
		γ Lyræ	19 0 16.87	+0.06	+0.18	+0.10	17.21	14.85	2.36	
		ζ Aquilæ . . .	5 40.57	+0.16	+0.15	+0.08	40.96	38.49	2.47	$a = +0^s.330$
		ι Lyræ	8 51.31	+0.03	+0.20	+0.10	51.64	49.34	2.30	$c = +0^s.080$
		d Sagittarii . . .	16 19.79	+0.30	+0.09	+0.08	20.26	17.76	2.50	
	W.	τ Draconis . . .	23 59.73	−0.60	−0.17	−0.28	58.68	56.06	2.62	
		β Cygni	31 41.90	+0.09	−0.06	−0.09	41.84	39.72	2.12	
		κ Aquilæ . . .	36 10.95	+0.25	−0.01	−0.08	11.11	8.67	2.44	
		γ Aquilæ . . .	46 20.09	+0.17	0.00	−0.08	20.18	17.87	2.31	
		α Aquilæ . . .	50 42.15	+0.18	+0.02	−0.08	42.27	39.91	2.36	
		ε Draconis . . .	54 37.49	−0.46	+0.11	−0.23	36.91	34.57	2.34	
		γ Sagittarii . . .	59 13.12	+0.13	+0.05	−0.08	13.22	10.87	2.35	
		3 Ursæ Maj., L. C.	20 6 20.57	+0.86	−0.04	+0.22	21.61	19.11	−6 2.50	
		SECOND SERIES.								
	W.	ι Pegasi . . .	21 22 20.05	+0.02	+0.06	−0.05	20.08	17.74	−6 2.34	$o = +0.33 + 15.00\,\delta t + 2.39\,a - 8.87\,c$
		β Aquarii . . .	31 0.63	+0.04	+0.03	−0.05	0.65	58.06	2.59	$o = -0.99 + 2.39\,\delta t + 31.06\,a - 11.49\,c$
		β Cephei . . .	33 5.40	−0.07	+0.05	−0.15	5.23	2.46	2.77	$o = -3.30 - 8.87\,\delta t - 11.49\,a + 76.52\,c$
		ξ Aquarii . . .	37 7.62	+0.04	0.00	−0.05	7.61	5.20	2.41	
		ε Pegasi . . .	44 4.66	+0.03	−0.02	−0.05	4.62	2.25	2.37	$a = +0^s.051$
		11 Cephei . . .	46 8.24	−0.07	−0.08	−0.15	7.94	5.30	2.64	$c = +0^s.051$
		μ Capricorni . .	52 30.98	+0.04	−0.03	−0.05	30.94	28.33	2.61	
		79 Draconis . . .	57 22.14	−0.09	−0.14	−0.17	21.74	19.12	2.62	
	E.	α Aquarii . . .	22 5 23.84	+0.03	+0.09	+0.05	24.01	21.33	2.68	
		ζ Cephei . . .	12 33.28	−0.03	+0.21	+0.09	33.55	30.92	2.63	
		θ Aquarii . . .	16 16.34	+0.04	+0.07	+0.05	16.50	13.84	2.66	
		γ Aquarii . . .	21 14.20	+0.03	+0.08	+0.05	14.36	11.57	2.79	
		π Aquarii . . .	24 55.70	+0.03	+0.08	+0.05	55.86	53.20	2.66	
		9 Draconis, L. C. .	30 24.57	+0.19	−0.20	−0.21	24.35	21.66	2.69	
		226 Cephei . . .	36 7.43	−0.11	+0.33	+0.20	7.85	5.30	−6 2.55	
		THIRD SERIES.								
	E.	α Andromedæ . .	0 7 57.79	+0.19	+0.23	+0.01	58.22	55.56	−6 2.66	$o = +1.83 + 13.00\,\delta t - 2.07\,a + 1.36\,c$
		22 Andromedæ . .	9 51.91	−0.07	+0.30	+0.02	52.16	49.71	2.45	$o = -9.00 - 2.07\,\delta t + 12.02\,a - 1.40\,c$
		γ Pegasi . . .	12 50.09	+0.35	+0.19	+0.01	50.64	47.92	2.72	$o = +0.50 + 1.36\,\delta t - 1.40\,a + 49.22\,c$
		Groombridge 29.	15 15.09	−1.80	+0.72	+0.05	14.06	11.24	2.82	
		ι Ceti	19 5.66	+0.59	+0.13	+0.01	6.39	3.63	2.76	$a = +0^s.746$
		12 Ceti	29 41.66	+0.54	+0.14	+0.01	42.35	39.64	2.71	$c = +0^s.012$
		ζ Cassiopeæ . .	36 3.58	−0.26	+0.32	+0.02	3.66	0.95	2.71	
	W.	α Cassiopeæ . .	39 28.30	−0.34	+0.09	−0.02	28.03	25.56	2.47	
		21 Cassiopeæ . .	43 30.70	−1.51	+0.12	−0.04	29.27	26.57	2.70	
		μ Andromedæ . .	55 51.77	+0.06	+0.05	−0.02	51.86	48.89	2.97	
		ε Piscium . . .	1 2 29.88	+0.43	+0.03	−0.01	30.33	27.43	2.90	
		β Andromedæ . .	8 46.85	+0.10	+0.04	−0.01	46.98	44.18	2.80	
		τ Piscium . . .	10 49.27	+0.18	+0.02	−0.01	49.46	46.76	−6 2.70	
Oct. 20	E.	α Lyræ	18 38 49.06	+0.10	+0.13	+0.28	49.57	40.97	−6 8.60	$o = +3.45 + 15.00\,\delta t + 0.62\,a + 3.88\,c$
		β Lyræ	51 34.61	+0.29	+0.09	+0.26	35.25	26.51	8.74	$o = -14.70 + 0.61\,\delta t + 9.44\,a - 6.22\,c$
		γ Lyræ	19 0 22.73	+0.31	+0.07	+0.25	23.36	14.79	8.57	$o = +3.12 + 3.88\,\delta t - 6.22\,a + 41.94\,c$
		ζ Aquilæ . . .	5 46.03	+0.83	+0.04	+0.22	47.12	38.42	8.70	
		ι Lyræ	8 57.37	+0.19	+0.02	+0.26	57.84	49.24	8.60	$a = +1^s.721$
		d Sagittarii . . .	16 24.47	+1.58	−0.01	+0.23	26.27	17.69	8.58	$c = +0^s.214$
		δ Draconis . . .	18 40.32	−1.97	−0.12	+0.56	38.79	30.18	8.61	
		τ Draconis . . .	24 7.03	−3.13	−0.15	+0.74	4.49	55.73	8.76	
	W.	β Cygni	31 48.09	+0.47	−0.14	−0.24	48.18	39.64	8.54	
		κ Aquilæ . . .	36 16.43	+1.21	−0.09	−0.22	17.33	8.60	8.73	
		γ Aquilæ . . .	46 25.94	+0.89	−0.12	−0.22	26.49	17.80	8.69	
		α Aquilæ . . .	50 47.96	+0.93	−0.13	−0.22	48.54	39.84	−6 8.70	

Observations at Ogden—Continued.

Date.	Clamp.	Names of Stars.	Observed Transit Corrected for Rate.	*Aa*	*Bb*	*Cc*	Corrected Transit.	*R.*	Corrections of Chronometer.	Normal equations.
1874.			h. m. s.	s.	s.	s.	s.	s.	m. s.	
Oct. 20	W.	ε Draconis . . .	19 54 46.36	−2.41	−0.41	−0.62	42.92	34.29	−6 8.63	
		γ Sagittarii . . .	59 19.10	+0.69	−0.17	−0.23	19.39	10.79	8.60	
		ε Aquilæ . . .	20 4 8.94	+0.98	−0.13	−0.22	9.57	0.88	−6 8.69	
		SECOND SERIES.								
	W.	12 Ceti	0 26 47.73	+1.24	−0.15	−0.21	48.61	39.67	−6 8.94	$o = +6.38 + 13.00\,\delta t - 1.78\,a - 9.00\,c$
		ξ Cassiopeæ . .	36 11.10	−0.60	−0.33	−0.34	9.83	0.96	8.87	$o = -16.65 - 1.78\,\delta t + 8.79\,a + 6.57\,c$
		α Cassiopeæ . .	39 35.96	−0.77	−0.36	−0.36	34.47	25.55	8.92	$o = -21.01 - 9.00\,\delta t + 6.57\,a + 42.75\,c$
		21 Cassiopeæ . .	43 40.78	−3.47	−0.65	−0.75	35.91	26.52	9.39	$a = +1^s.720$
		Bradley 82 . .	49 21.23	−1.46	−0 42	−0.46	18.89	9.56	9.33	$c = +0^s.203$
		μ Andromedæ . .	55 58.43	+0.14	−0.25	−0.26	58.06	48.90	9.16	
		ε Piscium . . .	1 2 35.88	+0.98	−0.17	−0.20	36.49	27.44	9.05	
		β Andromedæ . .	8 53.40	+0.22	−0.24	−0.25	53.13	44.18	8.95	
		τ Piscium . . .	10 55.68	+0.41	−0.23	−0.23	55.63	46.76	8.87	
	E.	υ Piscium . . .	18 44.42	+0.48	−0.03	+0.23	45.10	35.86	9.24	
		θ^1 Ceti	23 54.75	+1.34	−0.02	+0.21	56.28	46.78	9.50	
		38 Cassiopeæ . .	28 8.73	−2.36	−0.13	+0.58	6.82	57.98	8.84	
		η Piscium . . .	30 56.19	+0.79	−0.06	+0.21	57.13	47.70	−6 9.43	
Oct. 29	E.	ε Pegasi . . .	21 44 24.07	+0.34	−0.05	+0.15	24.51	2.08	−6 22.43	$o = -0.93 + 13.00\,\delta t + 4.46\,a + 7.92\,c$
		μ Capricorni . .	52 50.05	+0.54	−0.03	+0.15	50.71	28.16	22.55	$o = -11.35 + 4.46\,\delta t + 25.98\,a - 28.96\,c$
		79 Draconis . . .	57 42.26	−1.16	−0.23	+0.50	41.37	18.29	23.08	$o = +11.81 + 7.92\,\delta t - 28.96\,a + 59.16\,c$
		α Aquarii . . .	22 5 43.42	+0.43	−0.06	+0.14	43.93	21.19	22.74	$a = +0^s.638$
		ξ Cephei . . .	12 53.40	−0.33	−0.19	+0.27	53.15	30.54	22.61	$c = +0^s.144$
		θ Aquarii . . .	16 35.88	+0.50	−0.07	+0.15	36.46	13.70	22.76	
		γ Aquarii . . .	21 33.73	+0.43	−0.09	+0.14	34.21	11.43	22.78	
		π Aquarii . . .	25 15.34	+0.41	−0.09	+0.14	15.80	53.07	22.73	
		9 Draconis, L. C. .	30 43.41	+2.40	+0.28	−0.61	45.48	22.80	22.68	
		226 Cephei . . .	36 28.12	−1.41	−0.46	+0.58	26.83	4.44	22.39	
	W.	ζ Pegasi . . .	41 36.25	+0.33	−0.17	−0.15	36.26	13.14	23.12	
		η Pegasi . . .	43 31.16	+0.15	−0.22	−0.17	30.92	8.17	22.75	
		λ Pegasi . . .	46 53.23	+0.21	−0.20	−0.15	53.09	30.16	−6 22.93	
		SECOND SERIES.								
	W.	μ Andromedæ . .	0 56 12.21	0.00	−0.25	−0.22	11.74	48.92	−6 22.82	$o = -1.68 + 17.00\,\delta t + 0.10\,a - 4.86\,c$
		ε Piscium . . .	1 2 50.57	−0.03	−0.16	−0.17	50.21	27.46	22.75	$o = +1.08 + 0.10\,\delta t + 7.46\,a - 4.42\,c$
		β Andromedæ . .	9 7.26	0.00	−0.24	−0.21	6.81	44.22	22.59	$o = -6.86 - 4.86\,\delta t - 4.42\,a + 42.97\,c$
		τ Piscium . . .	11 9.81	−0.01	−0.22	−0.20	9.38	46.80	22.58	$a = -0^s.045$
		υ Piscium . . .	18 59.03	−0.01	−0.19	−0.19	58.64	35.91	22.73	$c = +0^s.172$
		θ^1 Ceti	24 10.05	−0.04	−0.10	−0.17	9.74	46.81	22.93	
		38 Cassiopeæ . .	28 21.66	+0.06	−0.40	−0.49	20.83	58.01	22.82	
		η Piscium . . .	31 10.97	−0.02	−0.14	−0.18	10.63	47.75	22.88	
		υ Persei	36 42.87	+0.01	−0.22	−0.26	42.40	19.64	22.76	
		φ Persei	42 13.41	+0.01	−0.24	−0.27	12.91	50.22	22.69	
		o Piscium . . .	45 10.89	−0.02	−0.14	−0.17	10.56	47.81	22.75	
	E.	ε Cassiopeæ . .	51 48.13	+0.04	−0.16	+0.38	48.39	25.65	22.74	
		β Arietis . . .	54 6.94	−0.02	−0.08	+0.18	7.02	44.26	22.76	
		50 Cassiopeæ . .	59 11.14	+0.07	−0.25	+0.55	11.51	48.70	22.81	
		γ Andromedæ . .	2 2 36.47	0.00	−0.14	+0.23	36.56	13.89	22.67	
		α Arietis . . .	6 30.37	−0.01	−0.10	+0.18	30.44	7.81	22.63	
		ξ^1 Ceti	12 45.46	−0.02	−0.09	+0.17	45.52	22.64	−6 22.88	
Oct. 31	W.	226 Cephei . . .	22 36 28.93	+0.43	−0.43	−0.64	28.29	4.30	−6 23.99	For W. $o = -2.94 + 5.00\,\delta t - 3.12\,a$
		ξ Pegasi . . .	41 38.06	−0.10	−0.11	−0.16	37.69	13.12	24.57	$o = +2.29 - 2.12\,\delta t + 6.29\,a$
		η Pegasi . . .	43 33.04	−0.04	−0.14	−0.18	32.68	8.14	24.54	$a = -0^s.194$
		λ Pegasi . . .	46 54.96	−0.06	−0.14	−0.17	54.59	30.14	24.45	
		ι Cephei . . .	51 38.61	+0.18	−0.29	−0.38	38.12	13.70	24.42	For E. $o = -1.60 + 5.00\,\delta t + 0.30\,a$
	E.	α Pegasi . . .	23 4 56.72	−0.70	−0.05	+0.16	56.13	31.71	24.42	$o = +19.99 + 0.30\,\delta t + 13.48\,a$
		π Cephei . . .	10 16.58	+3.12	−0.19	+0.60	20.11	55.77	24.34	$a = -1^s.492$
		o Cephei . . .	19 52.73	+1.72	−0.19	+0.41	54.67	29.97	24.70	Adopted $c = +0^s.158$ for E.
		υ Pegasi . . .	25 33.13	−0.52	−0.09	+0.17	32.69	8.17	24.52	
		λ Draconis, L. C. .	30 24.30	−4.07	+0.09	−0.46	19.86	55.39	−6 24.47	

Observations at Ogden—Continued.

Date.	Clamp.	Names of Stars.	Observed Transit Corrected for Rate.	*Aa*	*Bb*	*Cc*	Corrected Transit.	*R*	Corrections of Chronometer.	Normal equations.
1874.			h. m. s.	"	"	"	"	"	m.	
Oct. 31	E.	ε Cassiopeæ . .	1 51 48.86	+1.16	−0.20	+0.35	50.17	25.66	−6 24.51	$o = -2.38 + 11.00\,\delta t - 0.76\,a + 2.81\,c$
		β Arietis . . .	54 9.25	−0.54	−0.10	+9.17	8.78	44.27	24.51	$o = +9.44 - 0.76\,\delta t + 6.15\,a - 4.38\,c$
		50 Cassiopeæ . .	59 10.91	+2.30	−0.22	+0.51	13.50	48.71	24.79	$o = -11.48 + 2.81\,\delta t - 4.38\,a + 32.07\,c$
		γ Andromedæ . .	2 2 38.33	+0.01	−0.08	+0.21	38.47	13.90	24.57	$a = -1^s.413$
		α Arietis . . .	6 32.72	−0.47	−0.05	+0.17	32.37	7.83	24.54	$c = +0^s.158$
		ξ¹ Ceti	12 47.97	−0.78	−0.04	+0.16	47.31	22.66	24.65	
	W.	ε Cassiopeæ . .	25 11.92	+1.55	−0.57	−0.40	12.50	47.90	24.60	
		ξ² Ceti	27 56.85	−0.78	−0.21	−0.16	55.70	30.98	24.72	
		δ Ceti	39 30.93	−0.93	−0.19	−0.16	29.65	4.86	24.79	
		θ Persei	42 5.14	+0.28	−0.38	−0.24	4.80	40.29	24.51	
		μ Ceti	44 37.06	−0.75	−0.22	−0.16	35.93	11.30	−6 24.63	

N. B.—The instrument had to be taken from the pier every day on account of the carpenter being at work in the observing-room.

Corrections and Rates of the Ogden Chronometer.

Chronometer.	Date.	Local Sidereal Time.	Correction.	Hourly Rate.
	1874.	h.	h. m. s.	s.
Negus 1511 . .	Oct. 15	23.40	− 0 6 17.120	+ 0.0533
Negus 1491 . .	Oct. 16	23.23	− 0 6 2.660	+ 0.0801
	20	22.08	8.883	+ 0.0634
	29	23.81	22.742	+ 0.0367
	31	0.58	24.530	+ 0.0367

EXCHANGE OF SIGNALS.

The signals from Washington to Ogden were usually made by the clock. When the beats of the clock and the Ogden chronometer were nearly or quite in coincidence, arbitrary signals were sent by the observer, with the ordinary observing-key, at intervals of about ten seconds.

Signals from Ogden to Washington were usually made by the break-circuit chronometer, but when necessary arbitrary signals were sent with the observer's key, all signals being recorded, of course, on the chronographs at both stations.

On each night, repeaters were in the telegraph line at Pittsburgh, Chicago, Omaha, and Cheyenne.

October 15, signals W. to O., used the mean of 19 clock signals.
October 15, signals O. to W., used the mean of 19 chronometer signals.
October 16, signals W. to O., used the mean of 16 arbitrary signals.
October 16, signals O. to W., used the mean of 15 arbitrary signals.
October 20, signals W. to O., used the mean of 19 clock signals.
October 20, signals O. to W., used the mean of 16 arbitrary signals.
October 29, signals W. to O., used the mean of 14 arbitrary signals.
October 29, signals O. to W., used the mean of 12 arbitrary signals.
October 31, signals W. to O., used the mean of 14 arbitrary signals.
October 31, signals O. to W., used the mean of 19 chronometer signals.

Comparison of Signals.

Date.	Signals. Direction.	Signals. Station.	Clock and Chron. Time.	Correction.	Corrected Time.	Difference of Time. W. to O.	Difference of Time. O. to W.	Wave and Armature Time.
			h. m. s.	m. s.	h. m. s.	h. m. s.	h. m. s.	s.
Oct. 15	W. to O.	W.	1 38 30.526	− 0 49.716	1 37 40.810			
		O.	23 24 10.829	− 6 17.121	23 17 53.708	2 19 47.102		
								0.481
	O. to W.	W.	1 59 30.700	− 0 49.730	1 58 40.970			
		O.	23 45 10.526	− 6 17.139	23 38 53.387		2 19 47.583	
16	W. to O.	W.	2 1 36.707	− 0 49.977	2 0 46.730			
		O.	23 47 2.271	− 6 2.704	23 40 59.567	2 19 47.163		
								0.528
	O. to W.	W.	1 37 44.204	− 0 49.987	1 36 54.217			
		O.	23 23 9.199	− 6 2.673	23 17 6.526		2 19 47.691	
20	W. to O.	W.	2 20 30.526	− 0 51.238	2 19 39.288			
		O.	0 6 1.137	− 6 9.011	23 59 52.126	2 19 47.162		
								0.527
	O. to W.	W.	1 50 56.541	− 0 51.240	1 50 5.301			
		O.	23 36 26.592	− 6 8.980	23 30 17.612		2 19 47.689	
29	W. to O.	W.	2 39 36.161	− 0 53.053	2 38 43.108			
		O.	0 25 18.561	− 6 22.764	0 18 55.797	2 19 47.311		
								0.546
	O. to W.	W.	2 46 49.998	− 0 53.058	2 45 56.940			
		O.	0 32 31.852	− 6 22.769	0 26 9.083		2 19 47.857	
31	W. to O.	W.	3 38 25.464	− 0 53.480	3 37 31.984			
		O.	1 24 9.350	− 6 24.560	1 17 44.790	2 19 47.194		
								0.515
	O. to W.	W.	3 31 36.159	− 0 53.480	3 30 42.679			
		O.	1 17 19.526	− 6 24.556	1 10 54.970		2 19 47.709	
						2 19 47.186	2 19 47.706	0.519
						2 19 47.446		

No opportunity occurred for determining the *relative* personal equation between Mr. Clark and myself; and as the plan for obtaining *absolute* personal equations failed on account of the lack of the proper instruments, the above result is affected by the error of our personal equations.

The Transit Circle is $0^s.036$ west of the center of the dome of the observatory. Applying this correction, we have the center of the eastern pier in the transit room of the Ogden observatory

$$2^h\ 19^m\ 47^s.41$$

west of the center of the dome of the United States Naval Observatory.

Much of the success in transmitting signals was due to the skill of Mr. M. Marean, of the Western Union Telegraph office, who assisted with his usual zeal and kindness.

Very respectfully, your obedient servant,

J. R. EASTMAN,
Professor of Mathematics, U. S. N.

Rear-Admiral C. H DAVIS, U. S. N.,
Superintendent U. S. Naval Observatory.

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